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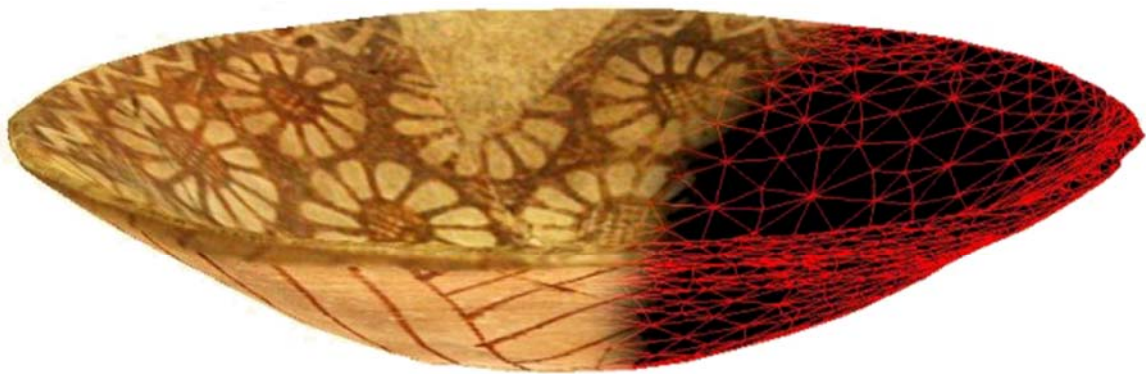
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The Virtual Vault Project:

Adventures in Digital Humanities Programming

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Center for Desert Archaeology**

November 18, 2009



*Three-dimensional model of Gila Butte Red-on-buff bowl
Hohokam Culture, A.D. 900–1150, Arizona State Museum # 77-32-331*

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Project Introduction

The Virtual Vault project was conceived as a way to employ digital humanities tools to share a portion of the Arizona State Museum's whole vessel collection in online digital exhibit contexts. Central to this initial conception of a digital interactive exhibit was the use of photorealistic three-dimensional digital models of ancient and ethnographic ceramics. These models were created using an ingenious process called *profile modeling* that, in 2007, allowed the Center for Desert Archaeology to rapidly digitize a significant sample of these ceramic objects. We hoped that an exhibit could utilize these existing assets to assist the Arizona State Museum in conveying the human history of Southwestern ceramics—from their development as simple utilitarian tools, to their refinement as ancient and modern art.

Our intention in developing this alpha-level exhibit prototype was to build a digital three-dimensional simulation of the compact storage system within the museum's actual "Pottery Vault," an on-site storage facility that holds the 20,000 whole vessels comprising the collection. The prototype was to be designed in a way that would enable people to explore the entirety of the collection, and then select specific sample vessels to explore with an interactive, three-dimensional vessel browser. The vessel browser, in turn, was to serve as an index for a variety of multimedia content concerning the vessel being examined. Ideally, this concept was intended to demonstrate an open-source standard for serving three-dimensional representations of heritage objects, both through an online browser, and via three-dimensional representations within Adobe's Portable Document Format (PDF) files. Our original aim was to demonstrate the potential of a Virtual Vault that could serve ten sample vessels.

Summary of Findings

As to be expected with any alpha-level prototype project, we encountered a number of surprises, successes, and failures in the development of the Virtual Vault. First and foremost, we found that the use of photorealistic three-dimensional representations of heritage objects, as created by profile modeling, is an ideal means of sharing ancient and modern ceramic objects. Because this concept was the central organizing principal of the Virtual Vault project, it is the opinion of the author and the evaluation committee that, in this respect, our efforts have achieved a basic degree of success for this endeavor. We have established a digital humanities asset for the Arizona State Museum (ASM) that can be utilized in a wide variety of educational and humanities contexts.

Unfortunately, we cannot claim that our efforts achieved a similar degree of success for some of our secondary goals for the Virtual Vault. By sharing a detailed and frank critical examination of the problems encountered in the development of the Virtual Vault, we hope to provide some notes of caution to other digital humanities developers.

The first critical problem with the Virtual Vault project relates to staffing and the nature of internet programming and programmers. At the start of the project, the lead programmer was injured in an automobile accident and resigned from the project. This led us to hire a series of contract web programmers, with unsatisfactory results. Our efforts were continually hampered by programmers who, despite excellent references and past histories of creative work, could not produce finished projects or meet project milestones in a timely manner. Unfortunately, the performance of two of the programmers hired for this effort bordered upon fraud.

This experience highlights a critically important problem with the state of Internet programming today: there are no standards for the performance of web programming, and there are no official certifications for web programming. Moreover, for programming projects at smaller, prototype-scale efforts, there is little practical legal recourse when programmers fail to produce contracted works. The potential addition of a penalty clause for late performance or failure to perform works in a contract for programming services was unacceptable to any of the programmers who were willing to work on the project.

A second problem relates to the use of “off-the-shelf” software packages and (ostensibly) standardized Internet programming protocols. Programming and scripting languages such as Javascript, Actionscript, and PHP are “evolving” rapidly, and when combined with a seemingly endless stream of security updates, the utilization of these tools often leads to unpredictable results. For the Virtual Vault, we relied upon a Javascript module to handle user interactions with the three-dimensional object models. With the release of Javascript version 1.8 in June of 2008, a flaw or bug in the Javascript interpreter prevented any of our vessel models from being served to a web browser more than once. Our programmers first had to overcome the natural confusion embodied in the cry “...but it worked yesterday!” and then find a fix for what Sun Microsystems eventually listed as a “known bug.” Similar problems were encountered when dealing with the ways that Adobe PDF files handle three-dimensional information.

Finally, a problem that could have been avoided entirely was the use of frameworks with our core PHP application. Although we could not find a replacement web programmer willing to work without the use of frameworks (a PHP code interpreter that simplifies programming tasks), in retrospect, this decision was a mistake—for many of the reasons listed above. Without standardization in web programming practices, it is not impossible that a security update for our framework could disable an aspect of functionality for our project.

All of these issues highlight an outstanding need for standardization and infrastructure for humanities computing. Our experience in developing a digital humanities application underscores the reasons why *Project Bamboo* and *Omeka* are critically important for the future of humanities computing. As discussed below, we strongly advocate the incorporation of a three-dimensional object standard for serving photorealistic three-dimensional models of heritage objects over the Internet.

Project History

The history of the Virtual Vault project builds upon the Arizona State Museum's legacy of unparalleled anthropological collections spanning the history of archaeological and museum practice in the American Southwest and Mexican Northwest. With support from the *Save America's Treasures* program, ASM completed construction of a curation facility to house the world's largest collection of whole vessels from the American Southwest. This collection—designated a national treasure by First Lady Hillary Clinton in 2000—provides a unique opportunity to share and interpret a significant assemblage of the world's cultural heritage (Figure 1).



Figure 1. Opening of the Arizona State Museum Pottery Vault Interpretive Gallery

ASM's whole vessel pottery collection is divided into two groups: archaeological ceramics and ethnographic vessels. The former includes ceramics systematically recovered from archaeological sites. The museum's holdings include the largest and most comprehensive collection of Hohokam pottery in this country; one of the largest collections of mountain Mogollon pottery; and the largest collection of northwest Mexican Casas Grandes pottery in the United States. Ethnographic material comprises items collected from historic and contemporary cultures, including one of the most significant collections of Hopi pottery in the country; the largest systematically collected assemblage of pottery from northwest Mexico (Tarahumara, Mayo, Pima Bajo, Yaqui, and Warihiro); the nation's largest collections of historic Apache pottery, contemporary

Navajo pottery, and eighteenth-century Tohono O'odham pottery; and significant examples of pottery made by the Maricopa and by Puebloan groups of New Mexico.

Upon completion of the Pottery Vault, ASM shifted its focus to devising the best means to share this collection with researchers, students, and the general public. The curation facility was originally conceived as a “Visible Vault,” where an open storage design would allow visitors to get a sense of the depth and breadth of the collection. Architectural and preservation constraints subsequently limited the visitor’s ability to examine and explore the collection. A “virtual vault” browser emerged as the most effective way to provide public access to the pottery; recognition of the potential for this tool to further the museum’s mission—particularly if it took the form of an Internet-based interactive exhibit—quickly followed.

At the same time discussions about the creation of a Virtual Vault were taking place, there occurred a number of developments regarding experimental techniques for creating low-bandwidth, photorealistic, three-dimensional object models from calibrated digital photographs. In 2006, Creative Dimension Limited released a program called *Three Dimensional Solid Object Modeler Professional*, or *3DSOM Pro*. This program utilizes advanced algorithms to extract three-dimensional models of objects photographed upon a calibrated target mat, and then exports these models to industry-standard three-dimensional modeling formats, as well as a Javascript-based implementation of a 3-D modeling format called *Koan*. Koan models represent a remarkably low bandwidth means of serving three-dimensional data, making such models ideal for Internet-based modeling projects.

The Center for Desert Archaeology immediately invested in the 3DSOM modeling system and began to prototype a number of existing vessels with an eye toward creating static, two-dimensional animations incorporating archaeological objects from ASM’s collections. Recognizing the exciting potential of this technology, ASM secured private funding that allowed the Center for Desert Archaeology to digitize one hundred vessels from the collection. In late 2007, the Arizona State Museum and the Center for Desert Archaeology applied for a National Endowment for the Humanities Digital Start Up Grant, which funded the research reported here.


Work on the Virtual Vault project began in early 2008. A Dell server was purchased to host the project. Almost immediately, we had to search for a new PHP programmer, as we lost our original lead programmer. Although a replacement programmer was hired in February of 2008, the contractor failed to produce any work on the project. A second programmer was engaged in May of 2008. This programmer installed a framework called *Kohana* on the project server; in retrospect, this proved to be a serious mistake. The second programmer was, however, able to establish the basic structure for the Virtual Vault project. Unfortunately, the programmer subsequently abandoned the project with about 75% of the effort completed. A final programmer was hired in June of 2009 to complete programming efforts, correct a variety of errors, and enable the installation of the Center for Desert Archaeology's Adobe Flash-based 3-D Vault Browser. Data population of the MySQL Database took place throughout 2009.

Regrettably, the disorder that resulted from the efforts of four different programmers limited the technical implementation of many of the secondary features planned for the Vault prototype. Of necessity, the use of digital audio and video has been discontinued. Although the source code for the Virtual Vault application supports such media, some minor technical problems currently prevent playback of streaming media files. The ability to automatically generate three PDF files from the Virtual Vault will never be properly implemented in this iteration of the of the application.

Methodology, Design and Implementation

It has always been our vision that the Virtual Vault project serve both public and professional audiences; therefore, we have incorporated a number of means that enable access to the virtual models of the pottery, to the tribal groups and traditions that these vessels reflect, and to the academic references suitable for further research on these objects. Upon viewing the initial user interface (Figure 2), a user can select among a traditional search function, an opportunity to view an item newly added to the database, the ability to browse items by cultural heritage, or an option to enter the 3-D Virtual Vault simulation. The search functions can be used to locate any vessel by any keyword

used in a vessel name, description, cultural affiliation, or ancient ceramic tradition, or by a numeric ASM vessel identification code.

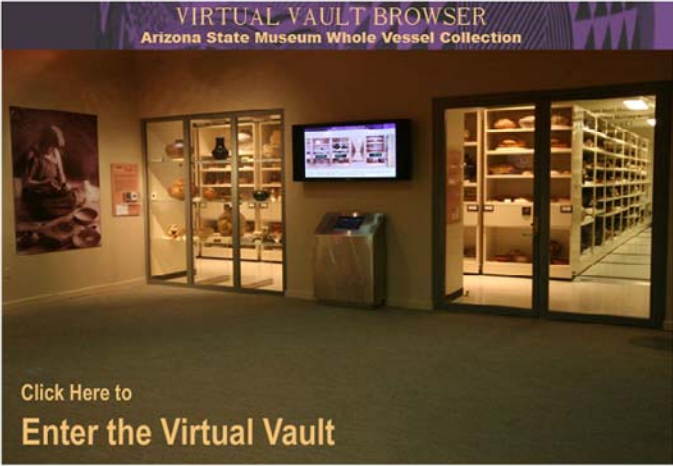

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Welcome to the Virtual Vault

The Virtual Vault – the result of a partnership between the Arizona State Museum (ASM) and the Center for Desert Archaeology – is a digital interactive of the Arizona State Museum's (ASM) Pottery Vault. It enables the visitor to "virtually" access a representative sample of ASM's collection of 20,000 whole Southwestern pottery vessels that spans nearly 2,000 years. Through digital renderings of pots, and archaeological sites, combined with contextual information and interviews with native potters, anthropologists and conservators, the museum can provide in-depth interpretation of this incomparable collection while maintaining proper environmental conditions and security. The Virtual Vault is being developed in conjunction with "The Pottery Project" a major new permanent exhibit at ASM, that includes the Pottery Vault, (a climate controlled storage and curation facility), a new state-of-the-art Conservation Laboratory and the Pottery Project Interpretive Gallery.




Click Here to
Enter the Virtual Vault


Share the Experience...

Share this Page


Recently Added Items




Tohono O'odham
Black-on-red Bowl with Frogs
O'odham
Tohono O'odham




Tohono O'odham
Black-on-red Bowl
O'odham
Tohono O'odham




Tohono O'odham
Black-on-red Plate
O'odham
Tohono O'odham



Tohono O'odham
Bean Boiling Pot
O'odham
O'odham



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Browse by Cultural Heritage

The groups below represent a pottery making cultural continuum spanning nearly 2,000 years. Originally representing a utilitarian "storage revolution," pottery has more recently come to be recognized as a fine art, with contemporary Native potters continually pushing artistic boundaries. Through technique, form and decoration, pottery has an altogether impressive capacity for cultural expression.

Acoma	Ancestral Puebloan	Ancestral Hopi	Ancestral Zuni
Ancestral Tewa	Apache	Chiricahua Apache	Cochiti
Colorado River Yuman	Hohokam	Hopi	Jemez
Jicarilla Apache	Laquna	Wariho	Mayo
Mogollon	Mohave	Nambé	Navajo
O'odham	Paquime	Patayan	Picuris
Quechan	Salado	San Ildefonso	Santa Clara
Santo Domingo	Tarahumara	Tewa	Zia
Zuni	Maricopa	Mexican	Seri
Tesuque	Isleta	Pima Bajo	Tepehuan

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Figure 2. Primary user interface for the Virtual Vault

The Virtual Vault Browser begins with a representation of the collapsed storage system within the physical Pottery Vault facility (Figure 3).

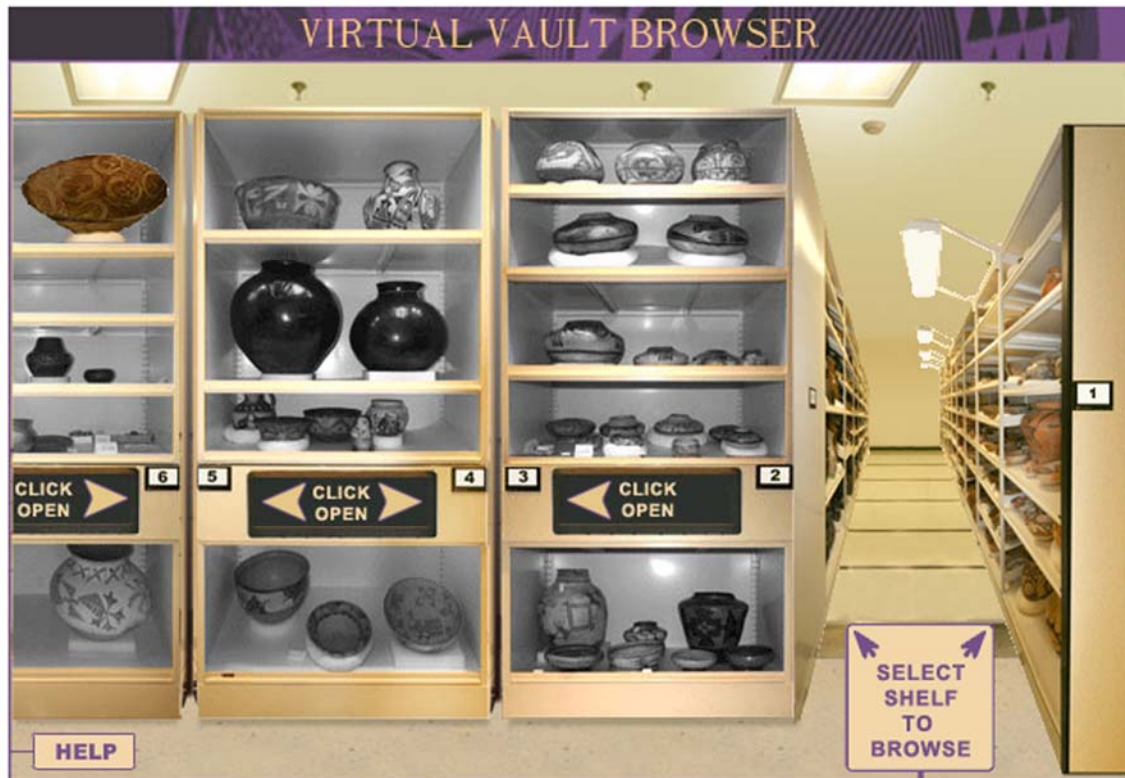


Figure 3. Virtual Vault display screen

It is at this point that the browser conveys the basic user interface concepts: first, that the vessels are stored on large, deep, mobile shelves that move to create access space; and second, that the use of color indicates that a vessel is “live” within the system. The use of roll-over highlights also furthers this idea and encourages user interactivity. Because our evaluation team pointed out that a color vs. grayscale metaphor would be lost upon color-blind browsers, we subsequently incorporated a small degree of motion to further distinguish live vessel icons from the thousands of vessels for which we do not have modeling data. At this point, the user may select a vessel from the shelf front, or the user may select a shelf row to browse. Once the user begins to browse at the level of a shelf row (Figure 4), the depth and breadth of the museum's whole vessel collection becomes apparent.



Figure 4. Vessel highlighted on the shelf-level browsing function

It is also important to note that the Virtual Vault browser portrays a fairly accurate representation of the physical Pottery Vault. Because we intend to install a copy of the Virtual Vault as a digital kiosk in the public gallery adjoining the collapsed storage, the ability to manipulate model shelves, as well as model pots, has tremendous interpretive potential.

Once a vessel is selected, a new window opens to the vessel display screen (Figure 5). The vessel display screen shows a wide range of information about the vessel in question, including: a timeline; an interactive 3-D model of the vessel from which detailed examination and real-time three-dimensional measurements may be made; a detailed description of the vessel; and a Google Earth interactive map displaying the origin of the vessel's manufacture, as well as the ancient distribution area of the pottery type it represents. For vessels from the museum's ethnographic collection, the origin of manufacture and the artist's name are displayed, rather than the distribution map. Research references are provided for both ancient and ethnographic vessels.

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775 AD
787
800
812
825
837
850
862
875
887
900 AD

Gila Butte Red-on-buff Bowl, Flower Motifs

Name: Gila Butte Red-on-buff Bowl, Flower Motifs

ASM #: 77-32-331

Culture: [Hohokam](#)

Ceramics: Hohokam Red on Buff

Dates: 775 AD to 900 AD

This vessel was collected from the Hardy site, Tucson in Pima County, Arizona.

The vessel is from the Arizona State Museum Archaeological Project (1976).

Manufacture & Distribution Map

Research over the last twenty years has shown that most Middle Gila Buff Ware vessels, like this Gila Butte Red-on-buff bowl, were made in a few villages located along the Gila River. They can be traced back to where they were made based on the distinctive material added to the clay to make it more workable and to prevent cracking of vessels as they dried out and were fired. The added material – called temper – used to make Middle Gila Buff Ware is crushed rock known as Pinal Schist. Besides crushed rock, ancient and modern groups have used sand, crushed sherds, and other materials for temper.

Archaeologists believe that production of Middle Gila Buff Ware by specialists was most pronounced during the Hohokam Sedentary Period (circa A.D. 950-1100). During this period, Hohokam ballcourts – and the ritual ball games played in them – brought people together from different villages, facilitating trade between communities. Archaeologists suggest that seasonal markets for the exchange of pottery vessels and other goods may have been associated with the religious observances surrounding ballcourt ritual.

This vessel was manufactured during what archaeologists refer to as the Hohokam Colonial Period (AD 775 - 900), and was probably made in a village in or near the Phoenix basin. During this time period, these vessels tended to be decorated with depictions of animals, human forms, or other natural motifs.

Reference List

Gladwin, Harold S., Emil W. Haury, E. B. Sayles, and Nora Gladwin. [Excavations at Snaketown: Material Culture](#). Globe, AZ: Gila Pueblo, 1937.

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Figure 5. Vessel display screen for the Virtual Vault

If you are reading the PDF version of this white paper, the pottery model in Figure 5 is fully interactive. You may rotate, enlarge, and examine this vessel.

The final implementation of the Virtual Vault Prototype is now available for review at the following URL:

<http://asmwebtest.asmuu.arizona.edu/exhibits/pvia/virtualvault/>

Adventures in Digital Humanities Programming

Our initial goal was to demonstrate the Virtual Vault concept with ten vessels for detailed browsing. We expected that adding vessel models would be difficult, but adding streaming media and PDF files would be relatively easy. Unfortunately, our expectations were reversed. Adding new vessels was quite easy, but coding the extra attachments depended upon having a reliable programmer at our disposal. For this implementation of the Virtual Vault, 140 vessels have been incorporated into the system, and the Center for Desert Archaeology has prepared another 235 vessels to add into the Virtual Vault system. For the downloadable PDF versions of our data display, ten vessels have attached PDF files; unfortunately, these files had to be assembled manually in Adobe Illustrator. Appendix 2 lists vessel identification numbers for the downloadable PDF models and vessel data sheets.

Evaluations of the Virtual Vault were, for the most part, uniformly positive. Numerous small technological issues were found and described in detail, but as this is an alpha-level prototype, we remain fairly confident in the interpretive potential of the Virtual Vault concept. However, we have now reached a stage in the project evaluation where we can conclude that the source code written for the vault project is not acceptable for further development. A lack of encoded comments, developer support, and a flawed “frameworks” model for programming have rendered this particular set of PHP coding into a virtual dead end.

Fortunately, almost all of the functionality of the Virtual Vault project has been developed in such a fashion that all of the digital assets for this project can be easily ported to a more “open” open-source content management system, such as Wordpress and—hopefully—Omeka. As noted previously, utilizing “off-the-shelf” commercial

three-dimensional applications carries a risk that the underlying coding systems may be re-written out from under end-user development efforts. Still, a benefit to this approach is that resulting media can be quickly transformed and utilized in other development efforts.

One exciting redeployment of Virtual Vault content has been the use of our pottery models in the University of Arizona LIVE Lab virtual “Cave” environment. The models employed in the Virtual Vault were converted to a three-dimensional virtual display of Southwestern ceramics in time and space, and then displayed in the interactive Cave. Figure 6 illustrates how the models of ancient vessels and modern art are displayed over a three-dimensional digital elevation model of the American Southwest and Mexican Northwest. Borrowing from the archaeological principal of superposition, the deeper a model is placed in this visualization, the older the vessel. Modern works of Native American ceramic art appear at the top of the collection, whereas the simple ancient seed jars that made sedentary village life possible represent the start of specific ceramic traditions. These traditions are then mapped in virtual space so that the vessels appear over the landscape in which they were originally manufactured and utilized.

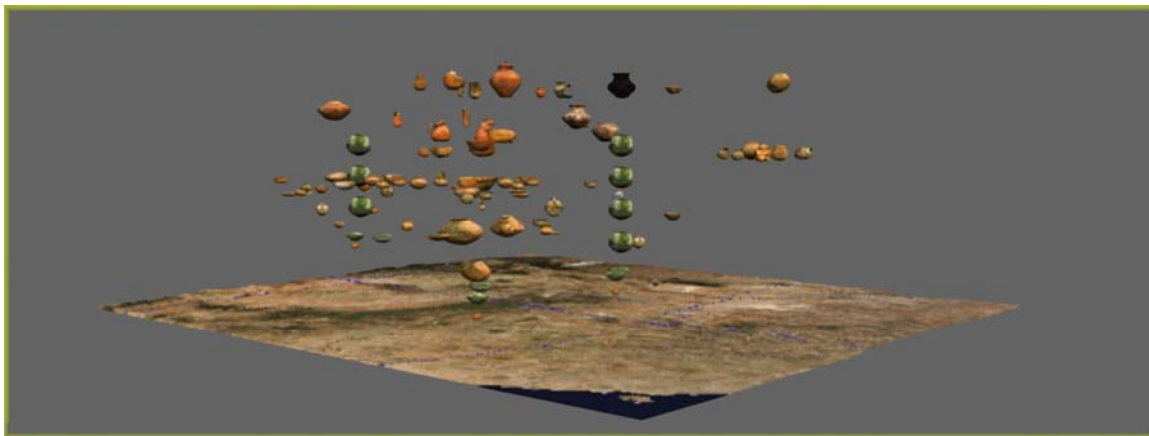


Figure 6. Southwestern pottery traditions in time and space

Visitors to the University Live Lab don the now-familiar 3-D goggles, and “fly” through a distribution of ancient and modern art (Figure 7). This kind of visualization experience allows people to quickly grasp some of the most basic ideas in the humanities of the Southwest. By illustrating how simple tools become complex and beautiful art forms, this type of visualization actually reconnects modern Native American people to

their ancient artistic heritage in a way that viscerally rejects modern mythologies of words like *Anasazi*, or western paternal notions of lost tribes and “collapsed” states. Almost 10,000 visitors to the Arizona Live Lab have experienced this visualization, and it is arguably the most popular visualization offered in the virtual environment.



Figure 7. Navigating the Arizona State Museum whole vessel collection in time and space

Recommendations

As discussed previously, this project is probably one of many that highlight the need for a standardized digital humanities infrastructure. Our efforts could have been better spent on developing additional humanities content, if we could have found a suitable content management system. In addition, we must recommend that if custom programming will be utilized, contracts with specific penalties for non-performance of

contractual obligations should be considered a mandatory requirement. Finally, teams should not conduct projects such as this without selecting back-up personnel. Random events can cause significant and debilitating project delays.

The next implementation of the Virtual Vault project will take the form of a Beta-level test that will utilize all of the content developed to date, but this content will be ported to a format proven to be more suitable for open-source collaboration. With suitable funding, we hope to serve more than one thousand vessels in this new design for a virtual museum.

Appendix 1–Digital Tools for Humanities Programming on the Virtual Vault

Because these white papers are intended to provide instruction for digital humanities scholars interested in furthering these types of experiments, I include a list of the tools utilized for this project, as well as some commentary on the strengths and weaknesses of various tools.

I) Creating low-bandwidth photorealistic 3-D models:

1) 3D Solid Object Modeler Pro 2.1 - www.3dsom.com

This is a fantastic tool for quickly making photorealistic models. The one downside to this tool is that the modeler cannot see object concavity. To achieve representations of concave objects, you will need a full 3-D modeler such as 3d Studio Max. 3dSom is particularly well suited for modeling globular or relatively simple geometric shapes, but without extensive tweaking, 3dSom does a relatively poor job of modeling objects with acute angles within the geometry.

Exports to: HTML(Java and Flash Implementations), VRML, 3ds W3d, and STL formats.

2) Strata Photo 3D CX - www.strata.com

A lower-cost version of 3dSom without options to deal with object concavity. Photo 3d CX can, however, model objects photographed without a calibrated target mat.

Exports to VRML and .3ds.

II) Working with models for 3-D on the Web:

1) Strata Live 3d CX - www.strata.com

Live 3d provided the best Javascript user interface for our 3d models, incorporating the ability to make measurements directly off of the digital models themselves.

Imports VRML, Koan 3d, Alias Wavefront Wireframes and .DWF

Exports to HTML via Javascript and to PDF.

2) Adobe Acrobat Versions 7 and up - www.adobe.com

Acrobat's secret 3-D feature is becoming more widely known, and PDF files can now support models of up to 20,000 polygons.

Imports the U3d Format. Adobe Acrobat Pro Extended may support more formats.

III) Working with raster images:

1) Adobe Photoshop

Photoshop is indispensable.

IV) Working with 3-D Files:

1) Adobe Photoshop CS 4

Photoshop is now a fully fledged 3d texture editor as well.
Imports 3ds, Collada, KMZ, U3d, & Wavefront OBJ files.
Exports Collada, KMZ, U3d, and Obj Layers.

2) 3d Studio Max

The “Swiss Army Knife” of 3-D tools. Also indispensable.

Appendix 2—Vessel Identification Numbers with Available PDF Downloads

6655
11744
94-134-442
A-7463
GP3640
2002-295-40
2003-437-1
2008-501-1
2007-413-1
2004-348-1